THE EFFECT OF HYDRIC STRESS AND SOIL ACIDITY ON SUNFLOWER SEEDLINGS

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ABSTRACT

This paper presents the effect of hydric stress on Select sunflower hybrid grown under near-neutral and acid soil conditions. The experiment was conducted in greenhouse with sunflower plants grown in PVC tubs filled with: near- neutral soil (pH = 6.2) (I), acid soil (pH = 5.27) (II) and ferti-lized acid soil [(phosphorus (100 kg/ha), potassium (100 kg/ha) and nitrogen (150 kg/ha)] (pH = 4.83) (III). Two watering regimes were used: five replications were watered daily and maintained at 70% from TSWC (total soil water capacity) (control variant) and five replications were watered once at a couple of days no more than 40% from TSWC (hydric stress variant). Significant decrease of leaf area, volume of root and dry matter accumulation was registered in sunflower plants under drought conditions. These modifications were more obvious under acid soil (albic luvisoil) as compared with near-neutral soil (cambic chernozem soil). The effect of fertilizers applied in acid soil on sunflower growth was positively significant. As a result, the growth of sunflower plants in this soil, under normal watering conditions, was higher than in the near-neutral and acid soils. For all that, under drought conditions, the leaf area, the volume of roots and dry matter accumulation of sunflower plants in fertilized acid soil significantly decrease as compared with near-neutral soil.

Key words: drought, hydric stress, soil water capacity, sunflower, watering regime.

INTRODUCTION

Plant growth and productivity are severely limited by the environmental stress including drought and soil acidity, both of them disturbing the plant metabolism.

Global change of climate has affected the Romanian climate by suddenly change of temperature, drought and flooding. The average air temperature in 2000 year arose with 1,8°C as compared with the previous year and also in this period rainfall has decreased in Romania with 33.4% as compared with the average annual rainfall.

In Romania there are 3,700,000 ha with acid soils which have the pH below 5.0 (Davidescu, 1969, quoted by Arsintescu, 1999).

Sunflower is a well preadapted to drought crop, essentially because of its powerful water uptake due to its efficient root system (Belhassen, 1995), but is very sensitive to soil acidity. There are few knowledge concerning the physiology and biochemistry of aluminium with regard to phytotoxicity in sunflower.

Taking into account these difficulties resulting from year-to-year variation of the meteorological conditions and sunflower characteristics, the study concerning the hydric and soil acidity effect on sunflower seedlings would be of a great interest for understanding the physiological response of sunflower to hydric and soil acidity stress. An improved understanding of these factors will facilitate planning further investigation into the causes of genotypic differences and improvement of methodology for genotype selection.

In the present study, the physiological response of sunflower seedlings under hydric and soil acidity stress is presented.

MATERIALS AND METHODS

Select sunflower hybrid provided by Sunflower Breeding Laboratory of R.I.C.I.C. Fundulea was used in this experiment.

The experiment was conducted in greenhouse, sunflower plants were grown in PVC tubs (35 cm long and 10 cm diameter) filled with: (I) cambic cernozem soil (pH = 6.2), (II) albic luvisoil (pH = 5.27) and (III) albic luvisoil fertilized with phosphorus (100 kg/ha), potassium (100 kg/ha) and nitrogen (150 kg/ha) (pH = 4.83).

Two watering regimes were used: five replications were watered daily and maintained at 70% from TSWC (total soil water capacity) (control variant) and five replications were watered once at a couple of days no more than 40% from TSWC (hydric stress variant).

Leaf area was expressed in square millimetres. The root volume was measured by water displacement from a filled beaker.

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The biomass of the above and below-ground parts was measured after drying it to the constant weight.

RESULTS AND DISCUSSION

As shown in figure 1, the decrease of leaf area as effect of hydric and soil acidity was significant.

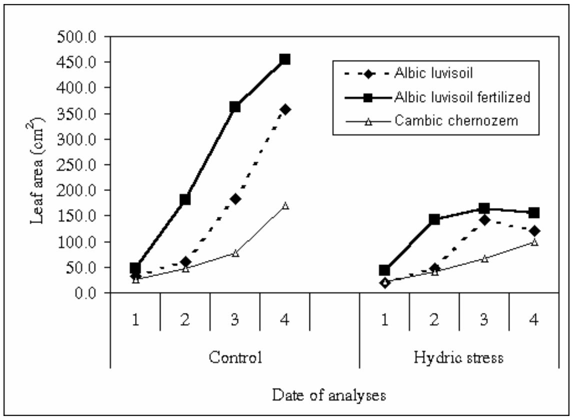

Figure 1. The effect of hydric stress and soil acidity on leaf area of sunflower at different dates of analyses: (1) four leaves; (2) 6-8 leaves; (3) 8-11 leaves; (4) 10-13 leaves

The negative effect of hydric stress and soil acidity on leaf area increases with the age of plants, but it is obvious that in chernozem cambic soil the leaf area has increased even under hydric stress conditions. Hereby the reduction of leaf area under acid soil conditions was with 70% higher as compared with 40% in chernozem cambic soil.

The growth of seedlings, as measured by shoot height, was significantly ($P<0.05$) greater in fertilized acid soil (326 mm) than in near-neutral soil (306 mm) and acid soil (278 mm). Why the growth of sunflower seedlings was greater in fertilized acid soil is unknown. Similar results were obtained by Hopkins and Taliaferro (1997) for *Panicum virgatum* in limed acid soil and their explanation is that perhaps greater crown and root disease pressure occurred in limed soil conditions, as has been reported for triticale and wheat (Murray et al., 1997). But under hydric stress conditions, shoot height was greater in normal soil (226 mm) than in acid soil (203 and 189 mm, this suggesting that the level of drought tolerance is greater in neutral soil (Table 1). Perhaps the differences in phosphorus availability under hydric stress were a factor of these results. Phosphorus availability is expected to increase as soil pH increases from strongly acid to near-neutral level (Troeh and Thompson, 1993).

Table 1. The effect of hydric and soil acidity stress on shoot height of sunflower (mm)

Soils	Experimental variants	Shoot height mm	Reduction of shoot height %
Acid soil	Control	306**	100
	Hydric stress	203^{00}	66.34
Fertilized acid soil	Control	324***	100
	Hydric stress	189^{00}	58.33
Near-neutral soil	Control	278	100
	Hydric stress	226	81.29

, * positively significant at 0.01 and 0.001 levels, respectively;
00 negatively significant at 0.01 level.

The biomass accumulation decreased concerning seedling growth under acidic and hydric stress conditions with 77, 42 and 31% for leaves, shoot and root, respectively (Table 2).

In our study, a significant decrease of the root weight of seedlings grown in fertilized acid soil (81%) was noticed vs. in near-neutral soil (4%) where the root weight was similar under optimal and hydric stress conditions (Table 2). The growth of seedlings expressed as biomass accumulation, as demonstrated by ANOVA analyses, is significantly influenced by hydric stress (B) and soil acidity (A), although a A x B interaction (F = significant for $P < 0.01$) may

Table 2. Combined effect of watering regime and soil type on the biomass accumulation and root volume

Soil type	Treatment	Biomass accumulation (g dry matter)						Root volume	
		Leaves		Shoot		Root			
		dry matter	%	dry matter	%	dry matter	%	cm^3	%
Acid soil	Control	5.50	100	1.37	100	1.23	100	15.9	100
	Hydric stress	1.21	22	0.79	58	0.84	69	9.1	57
Fertilized acid soil	Control	3.44	100	3.37	100	3.16	100	48.2	100
	Hydric stress	1.66	48	1.32	39	0.59	19	8.6	18
Neutral soil	Control	0.95	100	0.68	100	0.60	100	9.6	100
	Hydric stress	0.72	76	0.77	114	0.58	96	8.2	85

Table 3. Analysis of variance with F values for biomass accumultation and root volume of sunflower seedlings grown in acid and neutral soils

Source of variance	DF	F values		
		Shoot	Root	Root volume
Soil (A)	2	111.4305***	17.4257***	14.4516***
Error A	8			
Watering regime (B)	1	91.7757***	41.6628***	29.9024***
Interaction A x B	2	35.7767***	26.7996***	16.7795***
Error B	12			

have affected the results (Table 3). The similar results were obtained by Bona et al. (1992) for switchgrass.

The increase of root/shoot ratio was mentioned in literature (Sharp and Boyer, 1986) as an expression of plant adaptation to hydric stress. It is obvious that soil acidity disturbed the development of roots (Figure 2), this suggesting that in near-neutral soil the level of drought resistance is higher than in acid soil.

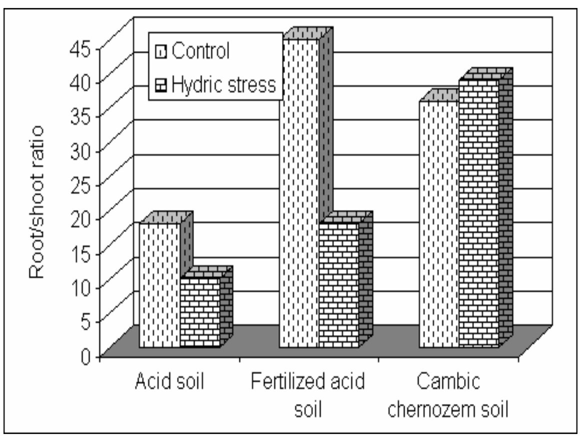

Figure 2. Combined effect of watering regime and soil type on root/shoot ratio

CONCLUSIONS

The effect of hydric stress combined with soil acidity determines a higher reduction of leaf area, root volume and biomass accumulation.

A stimulation of seedling growth under fertilized acid soil conditions is obvious.

The higher level of drought tolerance under near-neutral soil conditions is obvious.

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